

# Tank rehabilitation in India: Review of experiences and strategies

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## ABSTRACT

Traditional water harvesting (tank) systems are integral to agricultural development and livelihoods of rural communities in India. Despite the fact that these systems provide number of services (drinking water, protective irrigation, etc.), their importance and contribution declined during the post-independence India. Population pressure along with poor maintenance have led to their deterioration. For instance, the number tanks not in use has doubled between 2000-01 and 2010-11. The share of tank irrigation in total irrigation in India declined from 17% to 2.5% between 1950-51 and 2014-15. Realising the multiple benefits from these traditional systems, tank rehabilitation has been one of the policy priorities at the central as well as in some States.

This paper is a review of experiences on tank systems and their rehabilitation across the regions of India. The idea is to explore the variations in tank systems across the regions and identify specific approaches for strengthening and promoting them. Tank uses, benefits, users or stakeholders differ from region to region. Hence, the priorities may not be same in all the regions.

The evidence across the regions indicates that the benefits from tank rehabilitation outweigh the costs. It is argued that scaling up of tank rehabilitation at the national and state level is critical for providing substantial benefits to the local communities. While the policy initiatives to restore irrigation tanks are rational, the interventions need to be based on the changing conditions in terms of groundwater development and climate variability in the specific regions.

## 1. Introduction

In India, age-old water harvesting and storage systems such as tanks and ponds are becoming things of the past because of lack of any sort of maintenance by the state or civil society. These traditional systems have degenerated overtime because of unwarranted interventions by the state and changing socio-economic and political conditions at the village level. As a result, area under tank irrigation has declined substantially at the all India level i.e., 3.6 million hectares (17%) in 1950-51 to 1.7 million hectares (2.5%) in 2014-15<sup>1</sup>, though the extent of deterioration varies across states (CWC, 2010). This declining capacity of the tanks has not only led to loss of area under irrigation but also groundwater recharge in the tank dominated regions that are relatively dry, drought-prone and dependent on wells as tanks improve recharge by 40 per cent (Meter, et. al., 2016). Well irrigation recorded a phenomenal rise, especially during 1970s and 1980s and moved from second to the first position in terms of area irrigated by a single source.

This has, in turn, created considerable imbalance in the ecological and social systems of the country.

Declining tank irrigation and expansion of groundwater irrigation are observed across India, especially in the drought-prone regions. The literature identifies numerous socio-economic, institutional and physical reasons for the decline of tank irrigation (Von Oppen and Rao, 1980a; Reddy, 1990, 1995; Shankari, 1991; Janakarajan, 1993; Reddy et al., 1993; Palanisami, 2006 and 2008; Palanisami et al., 2011; Nehlin, 2016). The decline in tank irrigation has been linked with increasing population density (Von Oppen and Rao, 1980b). It has also been linked to the development of well irrigation (Palanisami, 2006). For, the decline in benefits from community-based technology/sources (tanks) has prompted people to shift towards individual-based technology/sources (wells). This, however, connotes a wrong notion of substitutability between tank and well irrigation, particularly because tanks complement groundwater development in reality. The decline of traditional systems, therefore, is a cumulative effect of policy and

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<sup>1</sup> Compiled from the Directorate of Economics and Statistics for different years, Ministry of Agriculture and Farmers Welfare, Government of India. Figures are provisional for the year 2014-15.

institutional neglect.

In the pre-independence past (before 1947), institutional arrangements such as *Dasabandam* and *Kudimaramat* of South India, *Aher-Pyne* systems of South Bihar; *Chandeli* tanks of Bhundelkh; and *Johads* and *Pals* of Rajasthan, were in place to protect these systems from decay. These institutional arrangements nurtured by the benevolent local rulers have been central to development and sustenance of the tank systems over centuries. However, the policy shift towards major and medium irrigation<sup>2</sup> during the British period, coupled with the changes in policy perception of irrigation development, that is, treating irrigation as a productive (revenue-generating source) rather than a protective source, has resulted in the degeneration of these institutions. In addition, overall environmental degradation, especially in drought-prone regions, has led to silting up of tanks and shrinking of their capacities. This, in turn, has led to the shift towards private well irrigation. Declining tank irrigation and expansion of well irrigation were slowed down towards the end of the British period and the slow down continued until the 1980s.

The second phase of the tank systems decline was triggered by the advent of the energization of groundwater lifting mechanisms. The new technologies in pumping systems during the 1980s coupled with the benefits from green revolution technology have resulted in an unprecedented expansion of groundwater development. Further, poor farmers were not in a position to adopt these technologies because of their capital-intensive nature, especially during the initial stages. Due to over exploitation (OE) a large number of open wells have started drying up in drought-prone regions. In fact, well failure (including borewells) has become a common phenomenon in the recent past, as the policies have been passive.

Realising the importance of protecting and sustaining these systems, tank rehabilitation programmes have been initiated by the state governments, bi-lateral agencies and Non-Governmental Organisations (NGOs) in number of states (Reddy, 2015). Of late, tank rehabilitation and modernisation has been initiated at the national level with budgetary allocations. While rehabilitation is defined as “bringing back the systems to their original technical form”, modernisation is defined as upgradation of the systems with modern infrastructure and management (Shah and Raju, 2002). Modernization thus also involves institutional arrangements for managing the systems. In fact, management is increasingly becoming critical for rehabilitating the systems. For, in the absence of appropriate and effective institutional arrangements investing in rehabilitation may not be a viable proposition. Therefore, rehabilitation and modernisation could involve number of activities such as strengthening the bund, sluice repair, de-silting, treatment of catchment, repairs to feeder channels and irrigation canals, institutional arrangements, etc., Some of these activities are taken up in the rehabilitation programmes, though institutional aspects are gaining importance in the recent years.

Although there is every reason to protect and strengthen these traditional systems, it needs to be based on the region specific nature and importance of tank systems. For, tank systems differ in their size, extent, functionality, management, etc., from region to region and hence requires specific approaches for their rehabilitation and management in a sustainable manner. The economic viability of tanks, given their scale, is crucial for the communities to realize their importance in improving their livelihoods. Tanks being common pool resources (CPRs), collective action is a prerequisite to manage them in a sustainable manner. This becomes important in the context of the changing socio-economic and political scenario. This paper is an attempt to explore the variations in tank systems across the regions and identify specific approaches for strengthening and promoting them across regions. Specific objectives include:

- Assess the extent and importance of tank systems across the four regions (North, South, East and West);
- Examine the various tank management practices across these regions;
- Examine various tank rehabilitation interventions and their impacts in different regions; and
- Suggest appropriate tank rehabilitation strategies in the changing socio-economic, environmental and policy context.

This paper is based on the literature available across the states and provides a meta-analysis of various aspects. This paper is organised in six sections: After the introductory section (one) the following section (two) presents the status of tank irrigation across the four regions of the country and sets the priorities for tank rehabilitation in these regions, section three provides the rationale and importance of tank rehabilitation interventions. Section four discusses the impact of tank rehabilitation programmes. The importance and nature of tank rehabilitation in the changing environmental and policy context is discussed in section five. And the last section (six) makes some concluding remarks and suggests region specific policy options.

## 2. Status and profile of tank irrigation across regions in India

### 2.1. Extent of tank irrigation

All the major States and Union Territories (UTs) in India are grouped under five regions (as per the Planning Commission) viz., South, North, East and West (Table 1). North-eastern states are not included here as there are no studies available for this region. Research on tank irrigation is mainly focused on south, east and western regions and very few studies are available from northern states. This could be due to the relative importance of tank irrigation in these regions or states. Irrigated area under tanks has been declining since 1950-51, while all other sources have recorded an increase (Fig. 1).

The Minor Irrigation<sup>3</sup> (MI) Census, carried out by the Ministry of Water Resources (MoWR), provide the information on tanks at the state level every five years since 1986-87. But only 2010-11 (MI) Census are the latest available<sup>4</sup>. Even the data provided in these Censuses are not consistent over the years. Only in one year (2000-01) number of tanks in use is given separately, while in other years tanks are given under surface water flows, which includes canal irrigation as well. These two figures are not comparable as tanks in use account for less than 50 per cent of the surface water flows and the 50 per cent decline between 1986-87 and 2000-01 in some studies (Pant and Verma, 2009) is not real (Fig. 2). Over the years there is an increase in the number of tanks from 0.5 million in 1986-87 to 0.64 million in 2000-01 and then they declined to 0.6 million in 2006-07. This may be due to watershed development programmes (WSDP) after the 1990s, under which number of surface water bodies are being created. Among the regions north and west have recorded an increase while south and east reported decline in surface water bodies between 1986-87 and 2006-07.

In the absence of accurate data across all the states, the number of tanks and ponds in India are reported to vary between 0.2 to 0.35 million (ADB, 2006). The number of tanks in use assessed by the MI census in 2000-01 was 0.23 million in India (Fig. 3). Besides, an estimated 42,955 tanks were not in use in 2000-01, which has gone up to 85,807 in 2010-11<sup>5</sup>. Together, this provides an estimate of number of tanks in the range of 0.3 million in India. Southern region accounts for

<sup>3</sup> Minor irrigation schemes are those with less than 2000 ha. of culturable command (irrigated) area.

<sup>4</sup> The data are released with a lag of 3-5 years. The 2016-17 Census data are likely to be available by 2020 at the latest.

<sup>5</sup> These figures are provided by indiastat.com. The actual year of reference is not clear as the data was sourced from a parliament question in 2011.

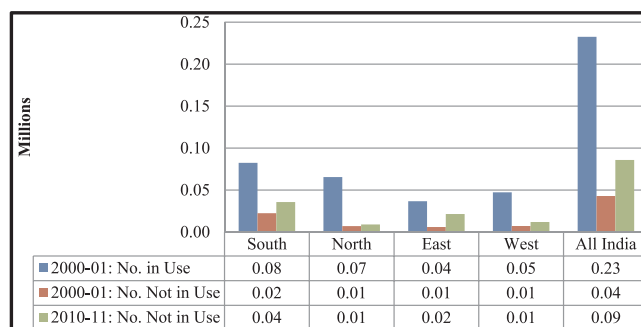
<sup>2</sup> Major irrigation schemes are those with a culturable command (irrigated) area of 10,000 hectares and medium irrigation schemes are those with 2,000 to 10,000 hectares.

**Table 1**  
Zone-wise Division of States.

North	East	West	South
Jammu and Kashmir	Bihar	Maharashtra	Andhra Pradesh
Punjab	Jharkhand	Goa	Tamil Nadu
Haryana	Odisha	Gujarat	Karnataka
Himachal Pradesh	West Bengal	Rajasthan	Kerala
Delhi			Pondicherry
Uttar Pradesh			
Uttaranchal			
Madhya Pradesh			
Chhattisgarh			

35 per cent of the total tanks in use in India (2000-01) followed by West (20%), East (16%) and North (14%). East has the highest proportion of tanks not in use (21,471 out of 42,740 in 2010-11) followed by south (35,742 out of 102,991 in 210-11), West and North. The high density of tanks in use as well as decayed tanks in South could be the reason for the focus the region received in terms of tank renovation programmes.

The variations in the density of tanks across states are basically due to geo-hydrological, topography and rainfall patterns. The topography of *Deccan Plateau* (South India) with undulating topography and rocky substrata are ideal for locating tanks and gravity irrigation. The geological formation of hard granite limits deep groundwater percolation warranting surface storage structures. In case of the plains in south Bihar and Chota Nagpur plateau, tank irrigation is an outcome of the natural condition and physical configuration of the area and has been evolved to overcome the obstacles of irrigation (ADB, 2006). On the other hand, most of the North Indian states have small ponds mainly for the purpose of inland fisheries, though they are also used for irrigation purposes. Thus, the density, prominence and importance of the tank

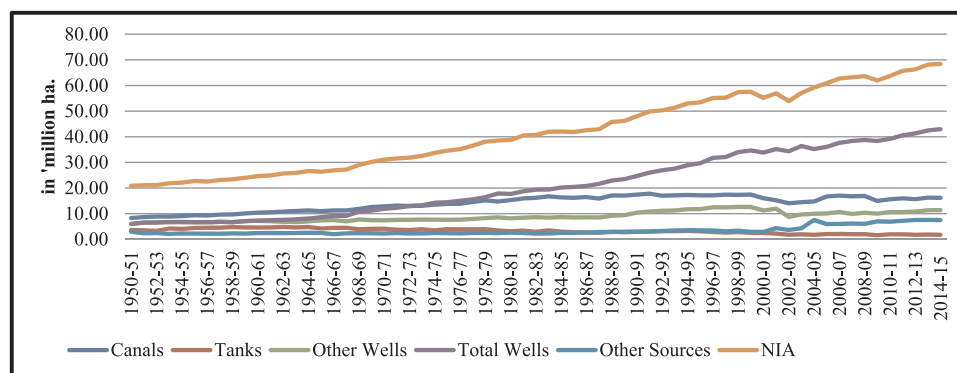


**Fig. 3.** Number of Tanks in Use and Not in Use across Regions of India: (Millions).

Source: GoI (different years), Compiled from Minor Irrigation Census, Ministry of Water Resources.

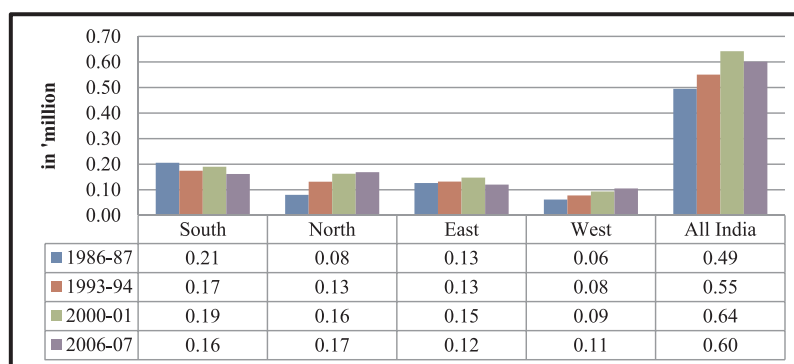
systems across the regions are critically linked to the natural and economic factors.

In the case of area under tank irrigation data are drawn from different sources and data are available till 2014-15. Area under tank irrigation between 1972 and 2008 has declined steadily in north and south regions as well as at the all India level, though there appears to be a sort of a revival between 2003 and 2008 (Fig. 4). This could be due to the advent of tank rehabilitation programmes in some of the southern and eastern states. Over the last 3 decades area under tank irrigation has declined by 1 million hectares at the all India level. Of this, more than 0.7 million hectares of area is from southern region consisting of AP, Tamil Nadu, Karnataka and Kerala. The share of different regions in the total area under tanks has declined between 1972 and 2008 in south and north regions i.e., from 58 to 53 per cent in south and from 14 to 9



**Fig. 1.** NIA by Source in India from 1950-51 to 2014-15 (Million Ha.).

Source: GoI (different years), compiled from: Directorate of Economics and Statistics, Ministry of Agriculture & Farmers Welfare.



**Fig. 2.** No. of Surface Water Bodies across the Regions of India (Millions).

Source: GoI (different years), Compiled from Minor Irrigation Census, Ministry of Water Resources.

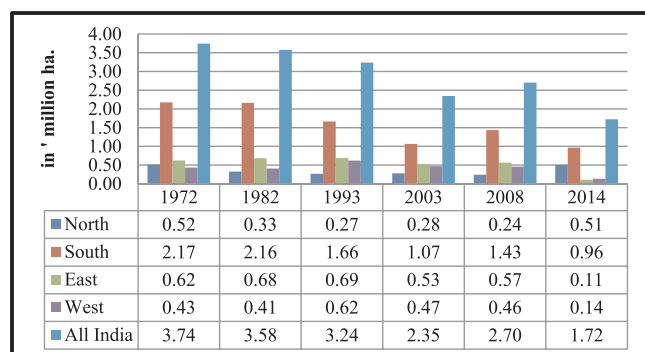


Fig. 4. Area under Tank irrigation over the Years across Regions: (million Ha.). Source: GoI (different years), compiled from: Directorate of Economics and Statistics, Ministry of Agriculture & Farmers Welfare.

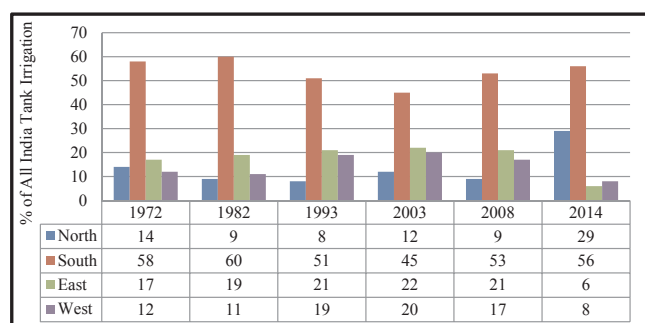


Fig. 5. Changes in Regional Contribution of Tanks to Total Area under Tanks in India over the Years (%).

Source: GoI (different years), compiled from: Directorate of Economics and Statistics, Ministry of Agriculture & Farmers Welfare.

per cent in north (Fig. 5). On the other hand, the share of east has improved from 17 to 21 per cent and in west from 12 to 17 per cent over the period. While South Indian states account for 35 per cent of the total tanks in use, they account for more than 50 per cent of the area. As per 2008 data the four southern states account for 53 per cent of the total area under tanks in the country followed by East India states (21%), West and North Indian states. Relative importance of tank irrigation in overall irrigation has come down substantially over years. At the all India level the share of tank irrigation has declined from 12 per cent in 1972 to 3 per cent in 2008 (Fig. 6). Within the respective regions also the importance of tank irrigation declined substantially over these years. Tank irrigation, however holds relatively greater importance in South and East India states. This could be one of the reasons for the

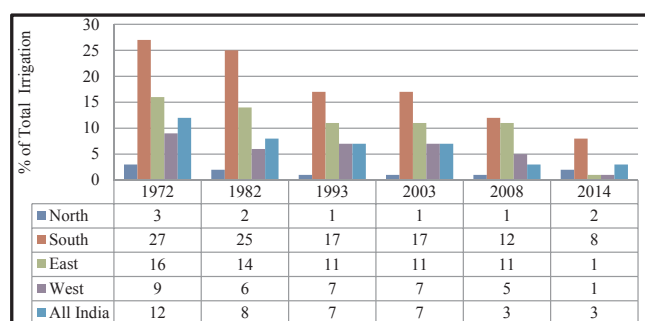


Fig. 6. Changes in Relative Importance of Tank Irrigation in each Region over the Years (%).

Source: GoI (different years), compiled from: Directorate of Economics and Statistics, Ministry of Agriculture & Farmers Welfare.

attention these regions get in terms of tank rehabilitation initiatives. Whereas tank irrigation accounts for 5 per cent of total irrigated area in West and 1 per cent in the North Indian states.

## 2.2. Nature of tank systems

Tanks are rainfall dependent and majority of the tank systems are located in arid and semi-arid regions with high temperatures. The weak relationship between rainfall and area under tank irrigation in states like Tamil Nadu could be due to degradation, encroachment and urbanisation (change in land use) of the catchment areas of the systems and the declining dependence on tanks over the years, especially after 1970s (Palanisami and Easter, 2000; Jana, et al., 2012; Narayanamoorthy and Suresh, 2016). That is run off is reduced or diverted from reaching the tanks. Tanks provide protective irrigation and the area covered is always more during the good rainfall years. In fact, in good rainfall years, farmers grow two crops under tanks, as the demand for water during *Kharif* is low in such years (Palanisami et al., 2008). In the recent years, tail end farmers of the distribution system receive tank water only during good rainfall years.

The size of the tanks is influenced by the magnitude and distribution of rainfall. Accordingly size of tanks varies across the regions. Most of the tanks have the submergence (water covered) area of less than 5 ha. (Pant and Verma, 2009; Palanisami et al., 2010). Their command (irrigated) area is less than 50 ha. in 80 per cent of the cases. The ratio of submergence area to command area differs from 1.5 to 4 acres in Southern and Eastern states. Jharkhand has the lowest ratio of 1.5. On the other hand, tanks in Western states like Rajasthan are described as bigger when compared to southern states. Tanks in Rajasthan have a command area of more than 500 ha. (Shah and Raju, 2002). This could be due to low and intensive rainfall in these regions i.e., less than 700 mm rainfall takes place in a few rainy days. On the other hand, in Tamil Nadu rainfall is distributed over a period of more than 6 months with an average annual rainfall of about 900 mm. On the other hand, eastern states of Odisha, Bihar, West Bengal and Jharkhand get fairly high rainfall of above 1000 mm. Due to the differences in rainfall and hydrogeology, the South India tanks were interlinked (cascading) in order to store as much water as possible from the seasonal rains. The ease of gravity irrigation in these regions has made them popular, even among the policy makers, over the years.

Historically, tanks have been constructed to store water in order to provide drinking water and protective irrigation during dry periods. In some regions like Bundelkhand, the *Chandeli* tanks were primarily built for recreation and domestic purpose and the numerous tanks in south were primarily built for protective irrigation purposes. Irrespective of the historical reasons, the British have converted most of these tanks in to irrigation tanks in order to increase their agricultural revenues (Shah, 2003). In eastern India majority of the tanks are multi-purpose for domestic use, irrigation and fish production though their primary purpose is irrigation (ADB, 2006; Pant and Verma, 2009; Kumar et al., 2011; Jana et al., 2012).

Tanks and ponds have been the primary source of water for poor rural households in eastern India, including Odisha. Recent research shows that they are being converted into fish ponds by local communities or Panchayats. This could be due to the declining viability of agriculture in general and specifically under tanks. For, inflows into the tanks have declined substantially in recent years due to the catchment interventions such as Watershed Programmes, urbanisation, etc., Though the tank systems have not been designed to facilitate multiple uses like domestic use, fisheries, livestock and irrigation, the systems by default become a multiple use systems due to anthropogenic pressure. While some of the unplanned uses may get absorbed by the system, other uses can damage it (Van Koppen et al., 2009). Often the competing water needs of the tanks results in conflicts between different users such as irrigators and fishermen. In the process some of the strident needs like drinking water or livestock water needs face severe



stress. And the poor become the first victims in the process as they are kept out of the process.

In Bundelkhand also tanks are being used for multi-purposes, though fishing seems to be the dominant activity of late (Shah, 2003). Irrespective of these direct or primary benefits tanks serve number of socio-ecological purposes like soil and water conservation (reduced run-off), groundwater recharge and enhanced resilience in the context of floods and drought, provision of highly fertile silt, etc., Some of these uses or benefits contradict the interests of primary beneficiaries like those getting low cost irrigation. For instance, in Rajasthan the interests of farmers who cultivate the tank bed conflict with the interests of command (irrigated) area farmers (Shah and Raju, 2002). The purpose for which the tank is being used in the socio-economic context is critical for the sustainability of the systems. For instance, if tanks provide substantial irrigation benefits in agrarian communities they are likely to be maintained better due to local interests. In the case of Bundelkhand greater economic benefits from fishing has prompted fishing groups taking more interest in taking over the tank management (Shah, 2003).

Tanks in Rajasthan are life savers in the arid conditions where rainfall occurs only for a few days in a year. The main purposes of these tanks are protective irrigation, soil and water conservation, drinking water for human and livestock population. Livestock economy in Rajasthan is as important, if not more, as agriculture. These tanks help capture, conserve and store the little but intensive rainfall the region receives and in the process reduce soil erosion by cutting the pace and momentum of run-off waters. The stored water is used for protective irrigation as well as helps recharge groundwater aquifers, which provide a stable and reliable source of irrigation and domestic water supply. Tank silt provides the natural fertiliser for the degraded soils. Unlike large reservoirs and tanks in South India tank-beds in Rajasthan are used both for water-storage as well as for cultivation. As a rule, farmers grow winter and, sometimes, summer crops in tank beds after they are emptied. And the method of irrigation is different as the entire tank is emptied at one go to facilitate tank bed cultivation. This is known as 'inundation irrigation' which has its advantages and disadvantages apart from conflicting interests between tank bed and command area farmers (Shah and Raju, 2002; Raju and Shah, 2000).

### 2.3. Tanks and groundwater

There is a clear and close link between well irrigation and tank storage, especially in areas with confined aquifers with rock stratum at 40–50 feet below ground (Shah and Raju, 2002). Tanks by storing the runoff water for longer periods help recharging groundwater. As a result well owners are an important stakeholder group of the tank systems, they have conflicting interests with the command area farmers. In most of the regions benefits from groundwater recharge have exceeded the direct irrigation benefits from the tanks. In Rajasthan the benefits from improved productivity of wells due to groundwater recharge extends beyond command and tank bed areas (Shah and Raju, 2002). This is even reflected in the increased land values beyond command area and hence considered as the most valuable benefit farmer's gain from the tanks. This is mainly due to the decline in the capacity of tanks resulting in shrinking of command area. In fact, groundwater irrigation in the tank commands is more reliable due to good recharge and also available throughout the crop season. In most cases tail end farmers mostly rely on groundwater due to unreliable water supplies from tanks. A U-shaped relationship between the number of private wells and tank degradation has been observed in Tamil Nadu (Balasubramanian and Selveraj, 2003). The interaction between tank irrigation (surface water) and groundwater levels is found to be strong in West Bengal (Chowdhury and Behera, 2018). In Tamil Nadu it was observed that tanks helps in increasing the recharge by 40 percent (Kimberly et al., 2016). It is argued that both tank irrigation and well irrigation should be used as complementary, rather than substitutes in order to maintain a hydrological balance and manage water resources sustainably in the

long run. Wells are also used as a mechanism to 'privatise' CPRs like tank water. As a result percolation tanks (PTs) are being preferred in place of irrigation tanks (Reddy and Behera, 2009a). Indeed, there might be value in thinking of irrigation tanks primarily as PTs designed to maximize groundwater recharge over as large an area around the tank as possible.

More importantly, groundwater depth has improved substantially (above 20 per cent) in the case of restored tanks when compared with the control villages. In Rajasthan the practice of 'inundation irrigation' helps recharge the aquifers and also helps top soils retain enough moisture for *Rabi* crop apart from facilitating tank bed cultivation (Shah and Raju, 2002). The flooding also helps in filling the small upland ponds in the command area. Unlike in other states tank bed farmers are as important as command area farmers in Rajasthan. In fact, tank bed farmers are more influential than the command area farmers given their control on water release and flooding of the command area (Raju and Shah, 2000). In this process, while the tank bed farmers benefit from cultivating the tank bed with the available moisture, command area farmers benefit from groundwater recharge. Tank bed farmers also use groundwater for protective irrigation purposes. Thus, groundwater recharge is the main benefit from these tanks.

On the other hand, groundwater development is limited under the tank systems in the East Indian states like Odisha and also in parts of Tamil Nadu. Groundwater irrigation is limited to open wells due to the viability of swallow aquifers and better rainfall conditions in the eastern regions. In Tamil Nadu it was observed that there is potential to increase the well density by 25 per cent in the tank commands as only 15 per cent of the farmers have wells (Palanisami and Amarasinghe, 2008). Despite the declining area under tank irrigation in recent years coupled with the declining groundwater, conjunctive use of groundwater with tank water has not spread much. This is often due to low productivity of agriculture resulting in low capacity of farmers to invest in bore wells. This appears to be in contrast with other regions where tanks are abandoned due to the increased dependence on groundwater (Kajisa et al., 2006). This has disturbed the ecological balance between surface-groundwater dynamics. In the context of eastern region, where such balance seems to exist, there is need to explore the hydro-geological aspects in order to promote sustainable conjunctive use of groundwater along with tank water.

It is observed that surface irrigation sources like tanks are more equitable when compared to groundwater. This is mainly due to the riparian access to water and low cost nature of irrigation. At the all India level area under tank irrigation has fluctuated between 1976 and 1991 but it has expanded at an annual rate of 1.4 per cent in the marginal farm (< 1 ha.) category and just by 0.1 per cent in the case of small farm (< 2 ha.) category (GoI, 1992). In all other farms, with a holding size of more than 2 ha, tank irrigated area has declined and annual rate of decline varied from 0.9 per cent to 3.1 per cent. Despite the limited expansion of tank irrigated area, its role in promoting equity cannot be ignored since the share of small and marginal farm holdings in the total farm holdings in the tank command area is very high as of now. It was observed that poor farmers (less than 2 ha) still use a major share of tank-irrigated area in India, as their share in tank irrigated area has gone up from 40 per cent in 1970–71 to 55 per cent in 1990–91. On the other hand, the share of large farmers declined from 14 per cent to 6 per cent (Narayanamoorthy, 2007). These trends hold good across different states where tank irrigation still has a considerable presence, like AP and Karnataka, as large farmers are observed to be shifting to well irrigation. Besides irrigation, poor households also depend more on tanks for various other uses such as livestock grazing, fishery, etc., Consequently, poor households are observed to spend 100 per cent more labour than their on-poor counterparts on tank maintenance activities (Balasubramanian and Selveraj, 2003).

It was argued that the shift away from tank irrigation to groundwater irrigation may adversely impact equity due to the heavy investments required for well irrigation. For, poor farmers may not be able to

make such lump sum investments. This argument is often used against the conversion of irrigation tanks into PTs (Reddy and Behera, 2009a). But, field research indicates that there is a structural change in the ownership of wells in the recent years. It was observed that wells especially borewells, are no longer privy to large farmers, as more and more small and marginal farmers (SMF) seem to be investing in bore wells. This may be due to the availability of cheap quality pumps at lower prices during the recent years. Moreover, farmers are forced to invest, often with borrowed money, in borewells due to the drying up of open wells (Reddy, 2005). However, availability of groundwater is critically linked with the sustainability of groundwater recharge.

## 2.4. Ownership and management

In the Indian context, there is no historical evidence of construction and management of irrigation systems by farmers alone. Chanakya, the author of Arthashastra urged the rulers to assist the farmers in the construction of irrigation works besides extending various incentives. During the period 13<sup>th</sup>–16<sup>th</sup> century in the Vijayanagara Empire (now part of Karnataka), a series of tanks were built by rulers in which farmers participated voluntarily in the construction and maintenance though there were conflicts among the farmers. Similar is the case during the regime of Chola, now Tamil Nadu (Joshi, 1997). Tank systems across the country were built by benevolent rulers with some voluntary support from farmers and majority of the existing tank systems were constructed during pre-British period.

During the colonial period, irrigation was the exclusive responsibility of the Civil Engineering Department. The projects were conceived, executed and managed as top-down engineering projects (Stone, 1984). In South India, after the tanks were taken over by the State administration and a large number were in disuse due to neglect by the indigenous management of irrigation systems. The British administration hardly conceived of communal or local water rights not just in India but also in other parts of the world. Irrespective of the ownership, tanks are mostly used by communities across the country. Private ownership of tanks is greater at 37 per cent in the East Indian states of Bihar, Jharkhand, Odisha and West Bengal though 83 per cent of the tanks have open access as far as use is concerned. In West Bengal 77 per cent of the tanks have open access despite the fact that it has the highest proportion of tanks (64 per cent) under private ownership (Pant and Verma, 2009). However, the pattern of ownership may have to be taken in to account while initiating tank rehabilitation programmes.

Number of studies has observed that historically these systems have been managed on community basis across the country till the British rulers have interfered in their management. In fact, community management was promoted and supported by the rulers by providing incentives. These incentives are in the form of rent free land to the families that take the responsibility of tank management. These forms are known as *Dasabandam* in the South, *Sagar / Rakshya / Jagir* in the East (Reddy, 1990 and Pant and Verma, 2009). For instance, in Himachal Pradesh, out of 1,00,000 ha of irrigated area; 70,000 ha were managed by communal systems called *Khuls* (Coward, 1990). Maharashtra has the long history of development and management of private irrigation schemes. The irrigation department used to manage the State's canal systems and the basic irrigation management approach is called *Shejpali* although alternatives exist. It adopted a policy to create water user associations (WUAs) at minor canal level (with average command of 500 ha.); transfer Operation & Maintenance (O&M) responsibilities for the minor and smaller channels to the WUAs; allocate water to the WUAs through five-year agreements and charge WUAs for water on the basis of the volume actually taken (volumetric pricing).

The irrigation rights documented by the British era provide much of the social glue required for operating and sustaining these systems. Their cohesion now is dependent ultimately on property rights legitimised by the State rather than by local custom. In Madras, an Office of Superintendent of Tank Repairs was formed in 1809 and staffed by a

Civil Engineer. In 1858 Public Works Department (PWD) was created and put into operation. The PWD tried to induce *Kudimaramat* (people's maintenance through free labour) by enacting laws to make it mandatory. Five successive irrigation acts were passed to try to force farmers to maintain the tanks (Vani, 1992). But government kept asserting its own powers by saying that the maintenance of the tanks is the obligation of the villagers but not their right. In 1920, the Madras Village Panchayat Act was passed and tank irrigation was handed over to *Panchayats*<sup>6</sup>. Under this Act Panchayats were given few powers including the right to enforce *Kudimaramat*. This also was not successful because the government did not give the *Panchayats*, the right to tax citizens for public works.

During British period, irrigation was treated primarily as a means to protect crops from drought. Irrigation systems were designed to provide small amounts of water over large areas (Randhawa, 1983). Since independence, Indian engineers have followed the same principles designed by the British. Maloney and Raju (1994) and Sengupta (1991) have documented the farmer management of tank irrigation in South India. In the case of large-scale canal systems, it was assumed that farmers would take responsibility for management and often the construction of the lower levels of the irrigation systems specifically the channels below the outlet (Stone, 1984; Chambers, 1988). The central and State governments of independent India inherited the idea that most water rights belong to the State (Stone, 1984).

This trend has changed in recent years where, many State governments have adopted the principle of participatory irrigation management (PIM) through government orders. The Command Area Development (CAD) programme in the year 1973 became the major effort towards improving water use efficiency and productivity of irrigated agriculture (Sivamohan and Scott, 1994). According to Wade (1978), irrigated agriculture specialists felt that the greatest opportunities lay in improving the portions of irrigation systems managed by farmers, i.e., "below the outlet". Therefore, WUAs is one of the elements included in the CAD. Recognizing the importance of users in management to solve the main problems faced by the government in managing the irrigation systems, some States adopted participatory management policies though the policies differed from State to State (Reddy et al., 2002). In AP, all tanks that have command area of more than 50 ha. were brought under WUAs. And more than 80 per cent of the 10, 000 WUAs formed in AP pertain to tanks.

## 3. Tank rehabilitation

### 3.1. Rationale

The rationale for tank restoration is valid not only from the equity and stability points but also from the economic angle. For, per unit costs of restoration are marginal compared to creating new irrigation systems, canal or tank. Moreover, most of the river basins are approaching their irrigation potential and any further expansion in area under irrigation has to come from rain water harvesting (ADB, 2006). That is future food security is critically linked to protecting and strengthening these structures.

Tank restoration has another important benefit in terms of groundwater replenishment. There are two ways of restoring these traditional systems. One is restoring them to the old type for providing direct irrigation and another is to convert them into PTs. Though both of them have advantages and disadvantages, percolation tanks (PTs) seem to perform better in terms of productivity. On the other hand, irrigation tanks are more equitable. More investments and follow up measures are required to safeguard equity in PTs. Research on costs and benefits of rehabilitating irrigation tanks made it clear that benefits outweigh costs in all situations irrespective of tank size though benefits

<sup>6</sup> Lowest administrative structure in India

are proportional to the size of the tanks (Palanisam, 2005; Reddy and Behera, 2009a, 2009b; Kumar et al., 2011).

Recharging of groundwater appears to be one of most pressing reasons for tank restoration given the fact that groundwater is the single largest source of irrigation in most parts of India. It is observed that in the absence of replenishing mechanisms like tanks or canals water supply available from wells is much limited. In most regions open wells have dried up and water levels go down rapidly in the deep borewells in the absence of well managed tanks in the vicinity, especially during the low rainfall years (Reddy, 2005). And whenever canals / tanks do not get adequate supply, the wells located in the vicinity get poor recharge and the independent wells get almost negligible recharge due to low rainfall (Sivasubramaniyan, 2006). This not only emphasises the rational for the revival of tanks but also points to the need for conjunctive use of surface and groundwater resources.

Therefore, restoring these systems will go a long way in addressing the issues of food security, regional imbalances, ecological balance, etc., While there is urgent need for policy intervention in this regard, the need for managing these resources in a sustainable manner is equally important. As these systems fall under CPRs, collective action is a prerequisite for their management. Traditionally, local people through institutional arrangements managed these systems. These traditional systems of resource management have degenerated over time due to the state interventions and due to the socio, political and economic dynamics at the village level. As a result, irrigation under these water bodies too experienced a growing gap between capacities, often created much before independence and the net area irrigated (NIA). Loss of capacity of the tanks is not only the loss of tank irrigation but also loss of groundwater recharge in the tank dominant regions, which are relatively dry and drought-prone and dependent on wells as much (Reddy, 1998; Reddy and Behera, 2009a). In fact, the increase in well irrigation is identified as the single most important factor responsible for the collective management of tank systems in Tamil Nadu in recent years (Kajisa et al., 2006; Aubriot and Prabhakar, 2011).

Institutional arrangements such as *Dasabandam* and *Kudimaramat* in south; *Sagar / Rakshya / Jagir* in the east were in place to protect these systems from decay. Under *Dasabandam* or *Jagir* tank lands were created and given to a person in the village (*Poligars*) for the purpose of maintaining the tank. Under *Kudimaramat*<sup>7</sup> community voluntarily participates in maintaining the tank. It was observed that the government of Madhya Pradesh was managing the tanks better even during 1950s with institutional arrangements like *payment-parch-pani* system (Shah, 2003). Distributional equity was maintained as the tail enders get the water first under this system, which was imposed by the government *Chowkidar*.

It is observed that the changing socio-economic and policy context is not conducive for collective or community management of tank systems. If the community based tank management systems were controlled by the village power structures (Mosse, 1999) then these power structures no longer exist nor wield any power to manage the systems. Even the community based institutions like *Kudimaramat* are no longer attractive due to the availability of non-farm employment, increased employment opportunities within the village such as watershed development (WSD), employment guarantee programmes, etc., (Koichi, 2011). Therefore, the present policy orientation of focused on participatory development may not be appropriate. These approaches need to orient themselves with the changing socio-economic and market contexts and consequent dependence of the local communities and their conflicting interests pertaining to the tank systems.

Evolution of efficient institutions is often linked to the local

community's perceptions and dependence on the resource that is being addressed. Unless the needs and linkages of local communities with tank systems are understood in a broader context, the tank restoration programmes may not achieve the objectives. It was observed that tanks in Rajasthan, despite their degraded status, still serve number of purposes of the local communities. And rehabilitating them to their previous status may adversely affect the livelihoods of those who are presently benefiting from them (Shah and Raju, 2002). For instance, the 'inundation irrigation' practiced at present protects the interests of tank bed farmers as well as command area farmers. Renovating the tanks by desilting, canal lining, treatment of catchment area may go against the interest of the tank bed farmers while it benefits the command area farmers. Similarly, fishing is increasingly becoming economically more viable in North and East India. Restoring such tanks to the previous state in order to protect the irrigation benefits may result in conflict of interest. In the case of South Indian tanks well owners have become an important stakeholder group. Ignoring the importance of groundwater recharge and conjunctive use in the South Indian tanks may aggravate the conflicts between command area farmers and groundwater farmers.

### 3.2. Tank rehabilitation and modernisation programmes

Tank rehabilitation programmes were initiated during the early 1980s. Though bilateral agencies like European Economic Community (EEC), World Bank and Ford Foundation have supported rehabilitation programmes in states like Tamil Nadu. NGOs such as Professional Assistance for Development Action (PRADAN) and Tarun Bharat Sangh (TBS) in Rajasthan, Gram Vikas in Karnataka, Development of Human Action (DHAN) Foundation in Tamil Nadu and AP, Society for Promotion of Wastelands Development (SPWD) in different states, have also initiated programmes to revive these traditional systems. State governments were not only partners in the large initiatives but also initiated large tank renovation programmes on their own with the support from bilateral agencies like World Bank. During 2004-05 tank rehabilitation got the specific attention at the national level only after two decades of efforts in various states. A pilot scheme for Revival, Restoration and Rehabilitation (RRR) of water bodies to augment the storage capacities and to recover or extend irrigation potential was initiated at the national level. Working Committee of the Planning Commission recommended about Rs.70,000 million (US\$ 2, 33, 33 million). The Pilot Scheme envisaged a plan outlay of Rs.3000 million (US\$ 100 million) to be shared by Central Government and State Governments in the ratio of 3:1 and covers the water bodies with an irrigation potential of 40 ha. to 2000 ha. Initially the scheme was for a short period of two years though planned to link it with the programmes like National Rural Employment Guarantee Programme (NREGP) and the *Bharat Nirman*.

Tamil Nadu, Karnataka, AP, Maharashtra, Odisha and Rajasthan are among the first states all undertaking rehabilitation and reforms with the help of national and international aid. One of the first tank rehabilitation<sup>8</sup> programmes was piloted in Tamil Nadu with the financial support from Ford Foundation. In 1984 EEC and Government of India (GoI) have signed an agreement to rehabilitate 210 tanks. While the phase I of the programme was completed in 1989, the Phase II was completed in 1996 covering about 44,000 ha. of command area (ADB, 2006). World Bank had supported rehabilitation of 620 tanks under its Water Resources Consolidation Project (WRCP). National Bank for Agriculture and Rural Development (NABARD) also provided support for 109 tanks in two phases. Altogether 11,034 tanks have been rehabilitated under different programmes in Tamil Nadu.

Karnataka has its Community Based Tank Management Project (KCBTMP) started in 2002, to rehabilitate 2000 irrigation tanks through

<sup>7</sup> Though *Kudimaramat* is argued to be the creation of British rulers in order to shift the burden of tank management to local communities, it was observed that community management of tanks was mostly governed by the village power structure (Mosse, 1999).

<sup>8</sup> Rehabilitation was focused on desilting and strengthening the bunds and weirs



community participation on pilot basis. The Government of Karnataka (GoK) constituted an autonomous body called the Jala Samvardhane Yojana Sangha (JSYS) to oversee the entire task (ADB, 2006). The project had three components: i) providing enabling environment for the sustainable, decentralized tank management systems; ii) strengthening community-based institutions to take up development and management activities; and iii) undertake system improvements. The purpose is to rehabilitate the tanks and hand them over to the tank user associations (TUAs). There are 57 cluster facilitation teams (NGOs) working with the project. A significant number of women and traditionally marginalized communities are involved and represented in the project (Thinksoft, 2006).

The Maharashtra Government has undertaken similar project called the Maharashtra Minor Irrigation Project (MMIP). The project envisaged improvements to minor irrigation tanks, weirs, diversion weirs, storage weirs (*bhandars*) and lift irrigation schemes, with participation of farmers in management and operation. The project components provided support for institutional reforms and capacity building in water resources management (WRM), irrigation service delivery and complementary investments in improving and modernizing physical assets. *Pani Panchayats* would be established in the post-implementation phase to ensure equitable water distribution among the farmers (Thinksoft, 2006).

The Odisha Water Resources Consolidation Project (OWRCP) was initiated with World Bank assistance in 1996. Its components included scheme completions, systems improvement and farmer participation, basin planning and environmental action plan, water resources research and agricultural intensification, institutional reorganization and strengthening, resettlement and rehabilitation and development plan of the indigenous people. *Pani Panchayats* were created to deal with tank-level issues like water distribution, conflict-resolutions, etc., (Thinksoft, 2006). This is part of the major water sector reforms in the state. European Union has provided support for rehabilitating 47 tanks in 1997 with a focus on repairing distribution channels, apart from some support funding from NABARD (ADB, 2006).

AP is the first state to initiate irrigation sector reforms in India. Under these reforms all the tank systems with more than 45 ha. of command area were brought under Water User Associations (WUAs), which are expected to rehabilitate and manage the systems. However, since the reform focus was not tank rehabilitations, tank WUAs suffered due to limited funding available for rehabilitation (Reddy and Reddy, 2002). A new initiative named 'The Andhra Pradesh Community Based Tank Management Project' (APCBTMP) envisaged rehabilitating around 3000 tank systems with an estimated command area of about 2,50,000 ha. The ultimate development objective is to improve tank system-based livelihoods and strengthen community management of the selected tank systems. Main components of the project include: i) strengthening community-based institutions for system improvement and management, ii) livelihoods support services for tank system users and iii) post implementation project management. This is a 5 year programme covering 3000 tanks in three phases. National framework guidelines have been used to select the tanks for rehabilitation. The criteria include: a) tanks irrigating 75 per cent of the area irrigated using at two-stage selection and b) incidence of poverty at the *Mandal* level and having cropping intensity of less than state average. In the case of tank cascades, the entire cascade is to be taken up for rehabilitation (Thinksoft, 2006).

The newly formed Telangana state has embarked on an ambitious tank rehabilitation programme, viz., '*Mission Kakatiya*'. Under this programme it is planning to restore 9306 tanks every year (20% of total tanks) with an eventual target of restoring all 46,531 tanks in 5 years, in a phased manner to bring 0.45 million ha. in to command. Main activities include de-silting, repairing of sluices, weirs, etc., strengthening of tank bunds, repairing the feeder channels and re-sectioning of irrigation channels.

Rajasthan also has initiated tank rehabilitation along with its water

sector reform project supported by The World Bank viz., Water Resources Consolidation Project (WRCP). Another project supported by German Bank for Development Reconstruction (KfW) envisaged rehabilitation and modernisation of 1198 large tanks over a period of 10 years. Like the AP model, the irrigation reforms in Rajasthan also tank user associations were organised to facilitate : (a) improved utilisation of potential created, (b) better operation and maintenance of the systems and (c) equitable, reliable and efficient distribution of water, etc., (Raju and Shah, 2000).

#### 4. Impact of tank rehabilitation

None of the rehabilitation programmes across India has taken up a comprehensive rehabilitation of the systems. The most comprehensive among them is the World Bank supported ones where the activities included strengthening earthen bunds, reconstruction of totally damaged sluices, repairing surplus weirs, rehabilitating supply channels and drainage channels, repairing canal structures and selective lining of channels. The focus of European Community (EC) Project was to rehabilitate the distribution system and transfer the management to WUAs after providing adequate training on all aspects with specific emphasis on O&M. Lining of field channels up to tertiary level and improvement of catchment drains to harvest rainwater was the focus of NABARD funded projects. On the contrary, NGOs supported mainly desilting and increasing tank capacity activities. One common activity among all the programmes is to encourage beneficiary participation. In fact, community participation considered as the most important component that would ensure effective and sustainable impacts.

Impact assessment of the rehabilitation programmes are also limited to specific activities. There are very few research studies that have comprehensively assessed the impacts of the programme in terms of cost-benefit analysis (ADB, 2006; Reddy and Behera, 2009b). However, a few studies have attempted cost benefit analysis of a limited number of tanks. The focus of the impact studies has been on the improved availability water which is critical for determining the tank performance. Better availability of water in turn influences: area under irrigation, cropping pattern, yield rates, livestock, fodder, employment, distribution of water, etc., (Palanisami et al., 2008). The NGO experiments in tank rehabilitation have also emphasised livelihoods aspects of tank dependent communities (ADB, 2006). Some studies, however, have assessed the performance of tanks in general (Kumar et al., 2011) or linked to institutional arrangements (Sakthivadivel et al., 2004). Though these studies have not assessed the impact of rehabilitation, they provide insights in to the likely impact of tanks when they are fully functional.

Asian Development Bank (ADB) has compiled evidence on the impact of tank rehabilitation programmes in various states like Tamil Nadu, Pondicherry, Karnataka and Odisha. These programmes were funded by various agencies like EEC, World Bank, NABARD, NGOs, etc.,. The main activities include: repairs to main irrigation/drainage channels, lining of main irrigation channels, restructuring of tank sluices and weir, desilting of supply channels and tank beds, improvement to catchment areas; on-farm development works, land grading and shaping and construction of periphery bunds/embankments. These activities were carried out selectively in different regions rather than on each system. The evidence overwhelmingly supports the positive impact of tank rehabilitation programmes across the states. This is obvious because in most cases rehabilitation is in the form of improved storage, water distribution systems, etc., which have helped increase in area under irrigation. An additional social benefit is the equitable distribution of water viz., improved availability of water to the tail end plots, which are mostly owned by marginal farmers. It is observed that canal lining has resulted in water savings to the tune of 21 per cent (ADB, 2006).

The favourable impacts are also due to the methodology adopted by these studies, viz., using the before and after situations as against using



with and without situation. Moreover, most of these studies do not address the long term sustainability of the programme. When a more systematic assessment is followed the impacts are found to be moderate, especially in the major initiatives like the EEC programme in Tamil Nadu (Palanisami et al., 2008). This study comparing 25 EEC (modernised) tanks with 25 non-EEC tanks observed no significant differences in the performance (water availability, yield rates, incomes, etc.) between these two groups of tanks. The main reason for this is the absence of follow up maintenance activities in the programme tanks, where the systems were going back to pre-programme status. This clearly raises the sustainability of the rehabilitation programmes in the absence of budgetary provision for follow up maintenance. This is also reflected in other studies as where a major complaint from the farmers was that in most of the rehabilitated systems rehabilitation is treated as a one-time activity and after the programme is closed, neither the implementing agency nor the funding agency revisits the system to provide advice and/or to carry out minor modifications and repairs, if any (ADB, 2006). On the other hand, some of the NGO implemented programmes are observed to have performed better in terms of impacts and sustainability when compared to control tank systems (Reddy and Behara, 2009a).

Number of studies has reported substantial improvements in productivity, crop intensity, employment, livestock production, etc., Besides, availability of fuel wood also increased in most of the study tanks. Improved groundwater recharge is another important impact of tank rehabilitation. Rehabilitation has benefited both drinking water and irrigation wells in the command area and beyond. The augmented recharge directly benefits the land owning households and indirectly benefits the poor and landless through an increase in employment days. Water markets have become active and provided access to water even to the poor. Improved access to drinking water helps reducing the drudgery of women and children and improves quality of life. At the same time, extensive canal lining reduced groundwater recharge. In fact, use of tank storage for artificial recharge at times of scarcity (using tank as percolation pond) is fast catching up in Karnataka, where orchards and cash crops are replacing cereal crops and crop diversification is taking place under well irrigation (ADB, 2006). The activity of lining could become a conflict of interest between well owning and command area farmers.

Another important area of impact and conflict is the desilting of tanks, which is carried out in most of the NGO programmes and not in large donor funded rehabilitation programmes. Apart from improving the water storage capacity of the tank, application of tank silt to farm lands contributes to the land productivity. In a study of tank rehabilitation in AP it was observed that yield increases range between 20 and 40 per cent due to silt application (Davuluri, nd.). It also reduced the use of chemical fertilizers by about 50–60 per cent compared to earlier years. Desilting of tank and application of tank silt to farm lands on a regular basis is a traditional practice. From the economic point of view, it was estimated in the case of Karnataka, desilting is viable if there is market for silt (Gireesh et al., 1997). Of late, carrying out desilting activities is becoming difficult not due to economic reasons but due to shortage or lack of willingness on the part of labour to engage in such hard work. And there are not many takers for silt due to transportation costs. In the absence of demand for silt, it is often dumped outside the tank, which gets in to tank with the first rains. Given the high costs coupled with the problems of disposal partial desilting is recommended in the case of Tamil Nadu (Palanisami et al., 2010). It is also proposed that desilting can be combined with social forestry, which is practiced on tank beds in Tamil Nadu, in order to get twin benefits. The rate of return is estimated at 8 per cent from this combined activity. This would ensure benefits from enhanced storage capacity of the tank as well as the benefits of social forestry on the tank beds (Palanisami et al., 2010).

Low sustainability of tank rehabilitation in most regions is giving rise to the demand for PTs, especially in the regions with high well

density in the command area. PTs apart from recharging groundwater, improves availability of water for human and livestock for longer periods and also facilitates fishing activities. Though not many tanks are designed for percolation, most of the tanks that are in disrepair function like PTs. In a study of Tamil Nadu it was observed that half of the defunct tanks function as PTs by default (Palanisami and Meinzen-Dick, 2001). From economic angle also the conversion to PTs is more beneficial (net returns per hectare) when tanks used purely for irrigation, purely for percolation and mixed ones are compared (Palanisami and Amarasinghe, 2008). And such conversions are more conducive for small tanks under Panchayat Raj Institutions (PRIs).

However, PTs may adversely impact the distributional equity, as some of the farmers depending on low cost flow irrigation may be deprived, if they do not have capacity to invest in borewells (Reddy and Behara, 2009a). It was observed in a study of Tamil Nadu that only 15 per cent of the farmers have wells and there is potential to increase the numbers by 25 per cent (Palanisami and Amarasinghe, 2008). This in turn may lead to conflict of interest between well owners and non-well owners. In one such situation where farmers in the command area, who do not own wells, raised objections for conversion of tanks the problem was amicably resolved with an arrangement for assured water sharing between farmers with wells and those without wells. That is farmers without wells pay one third of their harvest to the farmers with wells for supplying water for their fields (Davuluri, nd.). However, the situation is fast changing as more and more farmers (including small and marginal) are investing in borewells with the declining cost of well irrigation (Reddy, 2005).

Besides, the improved employment avenues at the village and the surrounding areas has helped checking migration to a large extent (ADB, 2006; Palanisami et al., 2008; Reddy and Behara, 2009a). At the same time these opportunities are also proving detrimental in terms of peoples' participation in the tank rehabilitation activities. In fact, even agricultural operations are getting effected, especially after the advent of NREGP that assures employment for 100 days in a year, which is preferred by the communities. For, NREGP is treated as welfare programme rather than an employment programme i.e., good wages with less effort (Reddy, 2011).

The participatory approach adopted in the rehabilitation programmes has some social impacts as well. These include, equal participation of socially disadvantaged sections like Scheduled Castes (SCs) as members in the executive committees. This is mainly due to the representative and democratic approach of electing member to committees (ADB, 2006). This has given the much needed voice to these communities. Another social impact pertains to the reduced gender differences in wage rates due to the implementation of equal wage rule in most programmes including WSD. Besides, women participation and membership has been made mandatory in some of the recent reforms like WUAs.

Participatory institutions have become mandatory for any rehabilitation programme, as the initial assessments of the rehabilitation programmes have identified the absence of peoples participation as the reason for poor impacts (ADB, 2006). In a study of 41 tanks spread over 22 districts in 8 states observed that techno-institutional mechanisms are central to most of the best performing tanks across the country (Sakthivadivel et al., 2004). Participation is not only in terms of mandatory labour for cleaning up the feeder channels and distributaries and user contribution, but also for negotiating with the neighbouring and village communities. These negotiations help in evicting the encroachment of tank bed and feeder channels. In one of the EEC projects in Tamil Nadu, the farmers of the down-stream tank negotiated with the up-stream farmers to do repairs and improvement works for their feeder channel, so that downstream tank can get more water. The agreement was that downstream tank community allocate funds for upstream farmers. In one of the tanks in Odisha new channels to harvest more rainwater from the watershed were created by the community through voluntary labour.

It may be noted that most of the impact assessment studies are partial in their assessments, as they have neither included all the tank uses and benefits in their analysis nor taken the environmental and social impacts in to account. Even when multiple uses like irrigation, drinking water, livestock, fishing, etc., are considered studies have limited their analysis to economic values, as measuring the social impacts are difficult. Though environmental impacts can be assessed, the estimation procedures are cumbersome. Despite the partial assessment benefits from tank rehabilitation outweigh the costs in most cases. These benefits could be enhanced further through reallocation of available water between crops, seasons and activities (Kumar et al., 2011). However, how long these benefits sustain in the absence of post implementation financial and institutional support is a moot point. It was observed even in the NGO implemented rehabilitation programmes, over time peoples participation was limited to monetary contribution forcing the management committee (MC) to contract out the works (Davuluri, nd.). As a result there were allegations of misappropriation of funds by the MC and the committee became defunct soon after the implementation. And no efforts were made to revive the old committee or elect a new one leaving tank without any formal body to look after the regular maintenance.

## 5. Climate change and tank rehabilitation

The major impacts of climate change are likely to occur through water. Climate change predictions of The Intergovernmental Panel on Climate Change (IPCC) for South Asia (Indian Region) indicated  $0.5^{\circ}\text{C}$  –  $1.2^{\circ}\text{C}$  increase in temperature by 2020 (IPCC, 2007). Rainfall pattern is also likely to change in terms of distribution and intensity. While agriculture as a whole is expected to be mostly negatively affected rain-fed agriculture, where tank irrigation is concentrated, in particular is expected to be impacted differently under the climate change (IPCC, 2007). Rain-fed agriculture may have unexpected changes in its crop compositions and crop calendar as the pattern and structure of climatic variables may change. These unexpected changes could sometimes be beneficial when they are internalised. But mostly these impacts become cascading due to the various socio-economic changes taking place in these regions. Increasing commercialization, changes in gender and age composition of working farmers and lack of educated farmers in agriculture, increasing labour costs and declining labour productivity are some of the changes that complicate the situation on the ground. The cascading impact of all these changes accentuated by the climate variability seems to be driving the fortunes of the rain-fed farmers. More importantly the farming communities and institutions are unable to foresee these impacts and adequately prepare themselves to face the challenges.

On the other hand, some of the states in the Indo-Gangetic Plains such as Uttar Pradesh and Bihar may experience floods due to ice melt. Different regions may experience different kinds of water stress. Overall, the demand for water is likely to increase, especially during *Rabi* (November–February) season. Incidence of prolonged droughts and frequent floods may increase in the coming years. Conservation of moisture and water storage becomes critical for adapting to such climate changes. Tank systems should be designed in such a way that they can withstand and help mitigate the extreme situations. This calls for a systematic and comprehensive approach.

Tank systems should be made part of the overall water policy. As observed in most of the states, canal irrigation, tank irrigation and well irrigation are considered and treated as separate entities. Though some states like AP brought tank systems under WUAs, their approach to rehabilitating and managing these systems falls short of requirements (Reddy and Reddy, 2002). In the context of increased temperatures storage of water in sub-surface aquifers assumes importance to reduce evaporation rates. And tanks need to be connected to canal systems wherever possible in order to face water shortages and severe droughts. On the other hand, interlinking of tanks (cascading) becomes critical in

the event of excess precipitation and floods. This is possible only with a comprehensive approach of integrating the three sources of irrigation in a river basin or watershed context. Rainfall forecasts should be effectively used to predict likely nature of tank filling. Non-systems tanks should be converted into system tanks by linking the canal / river systems wherever possible, so that surplus water during heavy rains can be diverted to the tanks easily. The tank-chain should be restored to facilitate for the diversion of water from upstream (US) tanks to downstream tanks (DS). In all the future government spending programs on tanks, this should be made compulsory.

While an integrated approach is necessary across the country, the requirements of the systems could differ from region to region depending on the changes or expected changes in climatic conditions. For instance, the need and extent of desilting and the need for conversion of irrigation tanks in to PTs may vary from region to region (Palanisami et al., 2010). Regular monitoring of climate as well as hydrological data at appropriate scale is a prerequisite for sustainable resource management (SRM). At present climate as well as hydrology variables are measured at the block or sub-district level. This scale of observation does not reflect the village level reality making the information totally irrelevant to the farmer. Establishment of rain gauge and hydrological monitoring stations need to be at the village level and surface hydrology monitoring should be carried out for each tank system in a river basin. These systems are neither costly nor difficult to handle by the communities (Reddy, 2012).

Such information would help in identifying appropriate activities and investments in the context of climate change. For instance, partial desilting and increase in well density are observed to be more appropriate in the context of Tamil Nadu tank systems in order to cope with the impact of climate change in the future (Palanisami et al., 2010). Similarly, tanks connected to canals (system tanks) are expected to provide more opportunities for improvement compared to non-system tanks (Palanisami and Rosegrant 1995 as quoted in Palanisami et al., 2010). Generation of technical information at appropriate scale is a prerequisite for policy planning in the context of climate change.

## 6. Conclusions and strategies for policy

Traditional water harvesting systems like tanks are integral to agricultural development livelihoods of rural communities. Though the importance of these systems varies across regions and states of India they serve number of critical and strident purposes like provision of drinking water, protective irrigation, etc., The evidence from number of research studies across the regions is unequivocal in saying that the benefits from tank rehabilitation outweigh the costs. Therefore, the policy initiatives to restore irrigation tanks are rational as far as achieving the objective of improving rural livelihoods and alleviating poverty in drought-prone regions is concerned.

Scaling up of tank rehabilitation at the national and state level is critical for substantial benefits to the local communities. Despite two decades of efforts in various states, the proportion of tanks rehabilitated is less than ten per cent of the defunct tanks. Perhaps, same number, if not more, of tanks may be falling in to disrepair every year. Therefore, the efforts and allocations towards tank rehabilitation needs to be increased many fold. Though the review clearly shows that number of activities go in to tank rehabilitation, all the activities in a comprehensive manner are taken up only in a few cases. Each programme (funder) has its priority of interventions. Moreover, the priorities may not be same in all the regions nor they suit the local conditions. For, tank uses, benefits, users or stakeholders differ from region to region. Hence, tank rehabilitation strategies ought to be specific to the regional requirements. In what follows we present some general strategies common to all the regions.

Although the immediate benefits of tank restoration are conspicuous, sustaining these benefits in the long run is the crux of the problem. This aspect needs to be given due importance while scaling up

the programme, especially by government agencies. This calls for major policy initiatives at the national as well as state level. These include:

- 1 There is need for a comprehensive approach to water resources planning integrating canals, tanks and groundwater. Policy should treat the three sources of irrigation as complementary to each rather than considering them as substitutes. That is all the three sources of irrigation need to be brought under a management regime at watershed or river basin scale;
- 2 Technical aspects like geo-hydrology, soils, land use, etc., need to be made part of planning while designing tank rehabilitation;
- 3 Generation of climate and hydrological information at an appropriate scale should be given high priority at the national level. Some states are already planning to establish low cost rain gauge stations at the village level;
- 4 Allocations towards tank rehabilitation need to be enhanced in order to fasten the pace of rehabilitation. Financing of tank rehabilitation needs to be changed to asset based planning instead of the one-time programme based approach, in order to ensure sustainability of the tank systems in the long run. This could be done following a life-cycle cost approach (LCA) where capital (asset) management is part of project costing. This would help in enhancing the benefits from the livelihood and income support policies such as fishery, dairy and other allied activities;
- 5 This calls for permanent institutional arrangements that have constitutional validity as well as linkages and manage the tanks on a continuous basis. This would have double impact of managing the structures in a more systematic manner and using the fund flows efficiently;
- 6 The present participatory approach seems to over emphasise the voluntary participation. This may no longer be feasible in the changing socio-economic and policy context. Constitutionally recognised institutional arrangements with incentive and disincentives mechanisms in place could be the way forward;
- 7 Addressing the equity concerns, especially relating to groundwater in the context of PTs, is one of the important concerns. Number of experiments like Andhra Pradesh Farmers Managed Groundwater Systems (APFMAGS), well sharing and social regulation is going on in various states (Reddy et al., 2014). Lessons drawn from such experiments could help scaling-up of equitable and sustainable groundwater management; and
- 8 Though multiple uses of tank systems are not new, the economics of various activities like fishing are changing. These changing or new demands of the community need to be kept in mind while designing rehabilitation in order to avoid conflicts between different stake holders.

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